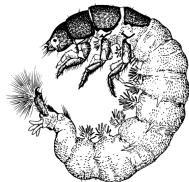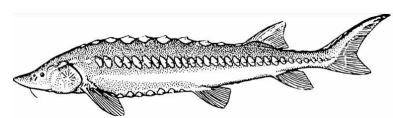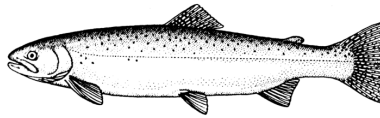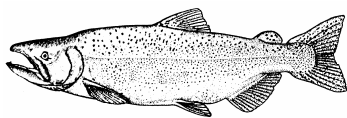IDENTIFICATION OF THE INSTREAM FLOW REQUIREMENTS FOR ANADROMOUS FISH IN THE STREAMS WITHIN THE CENTRAL VALLEY OF CALIFORNIA

Annual Progress Report
Fiscal Year 2008

U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
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Prepared by staff of
The Energy Planning and Instream Flow Branch
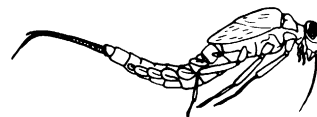
PREFACE

The following is the Seventh Annual Progress Report, Identification of the Instream Flow Requirements for Anadromous Fish in the Streams within the Central Valley of California, prepared as part of the Central Valley Project Improvement Act Instream Flow Investigations, an effort which began in October, 2001.[1] Title 34, Section 3406(b)(1)(B) of the Central Valley Project Improvement Act, P.L. 102-575, requires the Secretary of the Department of the Interior to determine instream flow needs for anadromous fish for all Central Valley Project controlled streams and rivers, based on recommendations of the U.S. Fish and Wildlife Service (Service) after consultation with the California Department of Fish and Game (CDFG). The purpose of this investigation is to provide scientific information to the Service's Central Valley Project Improvement Act Program to be used to develop such recommendations for Central Valley streams and rivers.

The field work described herein was conducted by Ed Ballard, Mark Gard, Bill Pelle, Rick Williams, Kevin Aceituno, Damon Goodman and Dan Cox.

Written comments or questions can be submitted to:

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[1] This program is a continuation of a 7-year effort, also titled the Central Valley Project Improvement Act Instream Flow Investigations, which ran from February 1995 through September 2001.

INTRODUCTION

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act provided for enactment of all reasonable efforts to double sustainable natural production of anadromous fish stocks including the four races of Chinook salmon (fall, late-fall, winter, and spring), steelhead trout, white and green sturgeon, American shad and striped bass. In June 2001, the Service's Sacramento Fish and Wildlife Office, Energy Planning and Instream Flow Branch prepared a study proposal to use the Service's Instream Flow Incremental Methodology (IFIM) to identify the instream flow requirements for anadromous fish in selected streams within the Central Valley of California. The proposal included completing instream flow studies on the Sacramento and Lower American Rivers and Butte Creek which had begun under the previous 7-year effort, and conducting instream flow studies on other rivers, with the Yuba River selected as the next river for studies. The last report for the Lower American River study was completed in February 2003, the final report for the Butte Creek study was completed in September 2003, and the last two reports for the Sacramento River were completed in December 2006. In 2004, Clear Creek was selected as an additional river for studies. In 2007, the Tuolumne River was selected for a minor project to quantify floodplain inundation area as a function of flow. In 2008, South Cow Creek was selected as an additional river for studies, with studies scheduled to begin in Fiscal Year (FY) 2009.

The Yuba River study was planned to be a 4-year effort, beginning in September 2001. The goals of the study are to determine the relationship between stream flow and physical habitat availability for all life stages of Chinook salmon (fall- and spring-runs) and steelhead/rainbow trout and to determine the relationship between streamflow and redd dewatering and juvenile stranding. Collection of spawning and juvenile rearing criteria data for fall- and spring-run Chinook salmon and steelhead/rainbow trout was completed by, respectively, April 2004 and September 2005. Field work to determine the relationship between habitat availability (spawning) and streamflow for spring-run and fall-run Chinook salmon and steelhead/rainbow trout was completed in FY 2005. Field work began in FY 2004 to determine the relationship between habitat availability (juvenile rearing) and streamflow for spring-run and fall-run Chinook salmon and steelhead/rainbow trout, and was completed by FY 2005 for all but two sites. Data collection on these two remaining juvenile rearing sites was completed in FY 2007. In FY 2007, we generated flow-habitat relationships for spring/fall-run Chinook salmon and steelhead/rainbow trout rearing for the segment downstream of Daguerra Point Dam and completed hydraulic modeling of the rearing sites upstream of Daguerra Point Dam. In addition, we completed the response-to-comments document for the peer review of the spawning study report and revisions to the draft spawning study report stemming from the peer review, and sent the draft report and response-to-comments document out for stakeholder review[2]. During FY 2008, we conducted a series of stakeholder meetings to discuss stakeholder comments regarding the draft spawning report and began a sensitivity analysis to further respond to concerns raised at those meetings. In FY 2008, we completed the draft rearing and redd dewatering/juvenile stranding reports and are making arrangements for peer review. Both of these reports will also

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[2] Stakeholder review for the Yuba reports was agreed upon during scoping meetings prior to commencement of the studies.

be sent out for stakeholder review, concurrent with the peer review. The remaining work on the Yuba reports is ongoing, including responses to stakeholder comments for the spawning report, and will continue in FY 2009.

The Clear Creek study is a 5-year effort, the goals of which are to determine the relationship between stream flow and physical habitat availability for all life stages of Chinook salmon (fall- and spring-run) and steelhead/rainbow trout. There are four phases to this study based on the life stages to be studied and the number of segments delineated for Clear Creek from downstream of Whiskeytown Reservoir to the confluence with the Sacramento River[3]. The four phases are: 1) spawning in the upper two segments; 2) fry and juvenile rearing in the upper two segments; 3) spawning in the lower segment; and 4) fry and juvenile rearing in the lower segment. In FY 2004 staff of the Service's Red Bluff Fish and Wildlife Office began collecting HSC data for spring-run Chinook salmon and steelhead/rainbow trout spawning and fry and juvenile rearing. Field work to determine the relationship between habitat availability (spawning) and streamflow for spring-run Chinook salmon and steelhead/rainbow trout in the upper two segments was completed in FY 2005. In FY 2007 the final report and the peer review response-to-comments document for spawning in the upper two segments was completed, as was data collection on two of the upper segment rearing sites and three of the lower segment spawning sites. In FY 2008, the data collection for three remaining lower segment spawning sites was completed and the 2-D hydraulic models for all five sites were completed and calibrated. Hydraulic modeling of the five spawning study sites in the lower segment is ongoing. Collection of HSC data for spring and steelhead/rainbow trout fry and juvenile rearing in the upper two segments continued in FY 2008. In FY 2008, we conducted habitat mapping and study site recon in the lower segment and selected juvenile rearing sites. We have begun data collection on all five lower segment rearing sites. We also completed fall-run Chinook salmon fry and juvenile rearing biovalidation data collection. We anticipate completing data collection for the five rearing sites during the first few months of FY 2009.

The following sections summarize project activities between October 2007 and September 2008.

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[3] There are three segments: the upper alluvial segment, the canyon segment, and the lower alluvial segment. Spring-run Chinook salmon spawn in the upper two segments, while fall-run Chinook salmon spawn in the lower segment and steelhead/rainbow trout spawn in all three segments.

YUBA RIVER

Hydraulic Model Construction and Calibration

Chinook salmon and steelhead/rainbow trout juvenile stranding and redd dewatering

Stranding flows and areas have been determined for all of the 76 juvenile Chinook salmon stranding sites (Appendix A). Using the HSC previously developed by the Service on the Yuba River for fall, spring-run Chinook salmon and steelhead/rainbow trout spawning, the percent loss of spawning habitat area versus flow was computed for Chinook salmon (fall and spring-run) and steelhead over a range of discharges. The redd dewatering analysis was conducted using data from the 2-D models for our 10 spawning sites. A draft report was completed in FY 2008. We will be sending this draft report out for concurrent stakeholder and peer review in FY 2009. We anticipate completing the final report in FY 2009.

Habitat Simulation

Chinook salmon and steelhead/rainbow trout spawning

A draft report and response to peer review comments document was completed in FY 2007. In FY 2007, we sent out the draft report to interested parties for review and comment prior to finalizing the report. This review by interested parties was in response to commitments made by the Service during the initial planning meetings with those interested parties. This is the first of the CVPIA instream flow reports to be reviewed in this manner. In FY 2008, we conducted a series of meetings with stakeholders regarding the draft report. In response to comments received at these meetings, we have begun a habitat modeling and biological verification sensitivity analysis to address these comments. To date, the sensitivity analysis has included different methods for developing criteria (density-based criteria), different methods of calculating habitat (geometric mean), and alternative criteria (specifically steelhead/rainbow trout spawning criteria that we developed on Clear Creek). With response to stakeholder comments ongoing, a final report on flow-habitat relationships for spawning and the response-to-comments document should be completed in FY 2009.

Juvenile Chinook salmon and steelhead/rainbow trout rearing

Computation of spring/fall-run Chinook salmon and steelhead/rainbow trout fry and juvenile rearing habitat over a range of discharges in was completed for all juvenile rearing sites in FY 2008. The draft report was completed in FY 2008. Peer review, response-to-comments document and a final report on flow-habitat relationships for rearing should be completed by September 2009.

CLEAR CREEK

Habitat Mapping

Juvenile fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

Mesohabitat mapping of Clear Creek was conducted January 7-10, 2008 for the Lower Alluvial Segment, which comprises approximately 8.3 miles of Clear Creek between Clear Creek Road and the confluence with the Sacramento River. The mesohabitat mapping excluded the 2-mile-long restoration area on lower Clear Creek. The mesohabitat mapping consisted of walking downstream from Clear Creek Road and delineating the mesohabitat units. Using habitat typing protocols developed by CDFG, Clear Creek was habitat mapped between the Clear Creek Road Bridge and the confluence with the Sacramento River. The location of the upstream and downstream boundaries of habitat units was recorded with a Global Positioning System (GPS) unit. The mesohabitat units were also delineated on the aerial photos. Following the completion of the mesohabitat mapping on January 10, 2008, the mesohabitat types and number of habitat units of each habitat type in each segment were enumerated, and shapefiles of the mesohabitat units were created in a Geographic Information System (GIS) using the GPS data and the aerial photos. The area of each mesohabitat unit was computed in GIS from the above shapefiles. A total of 166 mesohabitat units were mapped for the Lower Alluvial Reach. Table 1 summarizes the mesohabitat types, area totals and numbers of each type recorded during the habitat mapping process.

Field Reconnaissance and Study Site Selection

Juvenile fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

Field reconnaissance in January and February 2008 investigated potential study sites in the lower alluvial segment. Based on the results of the mesohabitat mapping and the field reconnaissance, a list of the potential study sites was developed. Using the final list of potential study sites, we selected five habitat study sites that, together with the five spawning habitat study sites, will represent the habitat types found in the lower alluvial segment. We attempted to randomly select four of the new habitat study sites to insure unbiased selection of the study sites[4]. However, upon revisiting one of the selected sites in preparation for study site set-up, it was determined that the presence of a series of beaver dams would make reliable water surface elevation data collection impossible. As a result, one of other selected study sites (a side channel run) was expanded to include a downstream side channel pool habitat to act as a replacement. The following is the final list of the five study sites, listed in order from upstream to downstream: Side Channel Run/Pool, North State Riffle, 3B, Tarzan Pool, and ACID Glide.

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[4] The fifth study site was selected to represent post-restoration habitat.

Table 1
FY 2008 Clear Creek Lower Alluvial Segment Mesohabitat Mapping Results

Mesohabitat Type	Lower Alluvial Units Area Totals (ft^2)	Lower Alluvial Number of Units
Side Channel Pool	52,176	21
Main Channel Pool	792,340	37
Side Channel Riffle	4,125	4
Main Channel Riffle	98,252	11
Side Channel Run	60,096	22
Main Channel Run	1,159,184	45
Side Channel Glide	3,601	3
Main Channel Glide	512,817	21
Cascade	24,980	2

Transect Placement (study site setup)

Juvenile fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

The 3B and Side Channel Run/Pool study sites were established in, respectively, January and February 2008, while the remaining three sites were established in May 2008. For the sites selected for modeling, the landowners along both riverbanks were identified and temporary entry permits were sent, accompanied by a cover letter, to acquire permission for entry onto their property during the course of the study.

For each study site, a transect has been placed at the up- and downstream ends of the site. The downstream transect will be modeled with PHABSIM to provide water surface elevations as an input to the 2-D model. The upstream transect will be used in calibrating the 2-D model. The initial bed roughnesses used by River2D are based on the observed substrate sizes and cover types. A multiplier is applied to the resulting bed roughnesses, with the value of the multiplier adjusted so that the WSEL generated by River2D at the upstream end of the site match the WSEL predicted by the PHABSIM transect at the upstream end of the site. Transect pins (headpins and tailpins) were marked on each river bank above the 1,000 cfs water surface level using rebar driven into the ground and/or bolts placed in tree trunks. Survey flagging was used to mark the locations of each pin. We also installed horizontal bench marks that act as control points for the bed topography data collection when using a robotic total station. After installing the horizontal bench marks, data was collected to establish a precise set of location coordinates for each horizontal bench mark using survey-grade Real-time Kinematic (RTK) GPS.

Hydraulic and Structural Data Collection

Fall-run Chinook salmon and steelhead/rainbow trout spawning (Lower Alluvial Segment)

Hydraulic and structural data collection for all five study sites (Shooting Gallery, Lower Gorge, Upper and Lower Renshaw and Upper Isolation) was completed in FY 2008. Low, medium and high flow water surface elevations were collected for all five sites. Velocity sets were collected for the transects at all five study sites. Depth and velocity measurements were made by wading with a wading rod equipped with a Marsh-McBirney^R model 2000 or a Price AA velocity meter. A tape or an electronic distance meter were used to measure stations along the transects. Substrate and cover (Tables 2 and 3) along the transects were determined visually. Dry bed elevations and substrate and cover data along the transects were collected and the vertical benchmarks were tied together at all five sites.

We collected the data between the inflow and outflow transects by obtaining the bed elevation and horizontal location of individual points with a total station, while the cover and substrate was visually assessed at each point. Bed topography data collection was completed for the five study sites. Validation velocity data collection for all five study sites was completed.   Stage of zero flow at the outflow transect was surveyed in for all five sites.

Juvenile fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

Vertical benchmarks (lagbolts in trees or bedrock points) were established and water surface elevations collected at all five rearing sites at low (~90 cfs) and medium (~200 cfs) flows. The vertical benchmark elevations have been tied-in for Side Channel Run/Pool, North State Riffle and 3B study sites. Velocity sets were collected for the transects at all five study sites. Depth and velocity measurements were made by wading with a wading rod equipped with a Marsh-McBirney^R model 2000 or a Price AA velocity meter. A tape or an electronic distance meter were used to measure stations along the transects. Substrate and cover along the transects were determined visually for all five study sites. Dry bed elevations and substrate and cover data along the transects were collected at all five study sites.

For all of the sites except the 3B site, we collected the data between the inflow and outflow transects by obtaining the bed elevation and horizontal location of individual points with a total station, while the cover and substrate were visually assessed at each point. Bed topography data for the 3B site is a combination of data collected by Graham Matthews Associates, and data that we collected using a survey-grade RTK GPS. Cover and substrate data for the 3B site was collected by delineating substrate and cover polygons with a survey-grade RTK GPS. Bed topography data collection has been completed for the Side Channel Run/Pool, North State Riffle and 3B sites and partially completed for the Tarzan Pool site.

Table 2
Substrate Descriptors and Codes

Code	Type	Particle Size (inches)
0.1	Sand/Silt	< 0.1
1	Small Gravel	0.1 – 1
1.2	Medium Gravel	1 – 2
1.3	Medium/Large Gravel	1 – 3
2.3	Large Gravel	2 – 3
2.4	Gravel/Cobble	2 – 4
3.4	Small Cobble	3 – 4
3.5	Small Cobble	3 – 5
4.6	Medium Cobble	4 – 6
6.8	Large Cobble	6 – 8
8	Large Cobble	8 – 10
9	Boulder/Bedrock	> 12
10	Large Cobble	10 – 12

To validate the velocities predicted by the 2-D model within Side Channel Run/Pool, North State Riffle and 3B sites, depth, velocities, substrate and cover measurements were collected in the site by wading with a wading rod equipped with a Marsh-McBirney model 2000 velocity meter. The horizontal locations and bed elevations were determined by taking a total station shot on a prism held at each point where depth and velocity were measured for the Side Channel Run/Pool and North State Riffle sites and with a survey-grade RTK GPS for the 3B site. A total of 50 representative points were measured throughout each site. We anticipate completing the hydraulic and structural data collection for the five rearing sites in FY 2008.

Hydraulic Model Construction and Calibration

Juvenile spring-run Chinook salmon and steelhead/rainbow trout rearing (Upper Alluvial and Canyon Segments)

The topographic data for the 2-D model (contained in bed files) is first processed using the R2D_Bed software, where breaklines are added to produce a smooth bed topography. The resulting data set is then converted into a computational mesh using the R2D_Mesh software,

Table 3
Cover Coding System

Cover Category	Cover Code
No cover	0
Cobble	1
Boulder	2
Fine woody vegetation (< 1" diameter)	3
Fine woody vegetation + overhead	3.7
Branches	4
Branches + overhead	4.7
Log (> 1' diameter)	5
Log + overhead	5.7
Overhead cover (> 2' above substrate)	7
Undercut bank	8
Aquatic vegetation	9
Aquatic vegetation + overhead	9.7
Rip-rap	10

with mesh elements sized to reduce the error in bed elevations resulting from the mesh-generating process to 0.1 foot where possible, given the computational constraints on the number of nodes. The resulting mesh is used in River2D to simulate depths and velocities at the flows to be simulated.

The PHABSIM transect at the outflow end of each site is calibrated to provide the WSEL at the outflow end of the site used by River2D. The PHABSIM transect at the inflow end of the site is calibrated to provide the water surface elevations used to calibrate the River2D model. The initial bed roughnesses used by River2D are based on the observed substrate sizes and cover types. A multiplier is applied to the resulting bed roughnesses, with the value of the multiplier adjusted so that the WSEL generated by River2D at the inflow end of the site match the WSEL predicted by the PHABSIM transect at the inflow end of the site[5]. The River2D model is run at

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[5] This is the primary technique used to calibrate the River2D model.

the flows at which the validation data set was collected, with the output used in GIS to determine the difference between simulated and measured velocities, depths, bed elevations, substrate and cover. The River2D model is also run at the simulation flows to use in computing habitat.

All data for the six spring-run Chinook salmon and steelhead/rainbow trout rearing sites have been compiled and checked. PHABSIM calibration has been completed for all six sites. Construction and calibration of the 2-D hydraulic models as described above for four of the six study sites was completed in FY 2007. Construction and calibration of the 2-D models for the remaining two study sites and running the production runs for the simulation flows was completed in FY 2008.

Fall-run Chinook salmon and steelhead/rainbow trout spawning (Lower Alluvial Segment)

All data have been compiled and checked, and hydraulic model construction and calibration was completed on all five study sites in FY 2008. Production modeling runs have been partially completed for all five study sites. We anticipate completing the production runs for all five study sites in early FY 2009.

Fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

All data collected in FY 2008 for the four study sites has been entered into spreadsheets. We anticipate completing hydraulic model construction, calibration and production runs for all five rearing study sites in FY 2009.

Habitat Suitability Criteria Development

Juvenile spring-run Chinook salmon and steelhead/rainbow trout rearing (Upper Alluvial and Canyon Segments)

Staff of the Red Bluff Fish and Wildlife Office have been conducting snorkeling surveys specifically to collect rearing HSC for juvenile spring-run Chinook salmon and steelhead/rainbow trout in the Upper Alluvial and Canyon segments. The collection of Young of Year (YOY) spring-run Chinook salmon and steelhead/rainbow trout (fry and juveniles) rearing HSC data began at the end of FY 2004 with surveys conducted on the dates in Table 4. Snorkel surveys were conducted along the banks and in the middle of the channel. Depth, velocity,

Table 4
Spring-run Chinook Salmon and Steelhead/Rainbow Trout Juvenile HSC Data Collection

Dates	Average Igo Flows (cfs)
September 24, 2004	213
January 14, 21, and 26-27, 2005	283
February 15, 2005	238
April 6 and 20, 2005	250
May 5, 11-13, 16, 23 and 26, 2005	264
June 7, 10, 13 and 23-24, 2005	198
July 28-29, 2005	154
November 22, 2005	199
December 7-8 and 14-16, 2005	216
January 25-26, 2006	194
February 10, 17 and 23, 2006	272
March 9-10, 15-17, 20-21, 27 and 29, 2006	378
April 6, 20-21, 24 and 26, 2006	333
May 1, 5-6, 9-10, 16-17, 24-25 and 30-31, 2006	262
June 6-7, 2006	136
July 5 and 14, 2006	95
August 8, 2006	89
December 7, 15, 18-20 and 29, 2006	240
January 5, 8, 10, 17-19, 25-26 and 30-31, 2007	217
February 1, 5-7, 13-15, 21 and 27, 2007	261
March 7, 2007	255
April 3, 5, 10, 13, 17 and 26-27, 2007	235
May 1, 11, 15-18 and 23-24, 2007	227
June 7, 19 and 21, 2007	167
July 10, 12 and 19-20, 2007	106
January 16-17 and 30, 2008	253
April 29-30, 2008	224

adjacent velocity[6] and cover data were also collected on locations which were not occupied by YOY spring-run Chinook salmon and steelhead/rainbow trout (unoccupied locations). This was done so that we could apply a method presented in Guay et al. (2000) to explicitly take into account habitat availability in developing HSC criteria, without using preference ratios (use divided by availability). Traditionally, criteria are created from observations of fish use by fitting a nonlinear function to the frequency of habitat use for each variable (depth, velocity, cover, adjacent velocity). One concern with this technique is what effect the availability of habitat has on the observed frequency of habitat use. For example, if cover is relatively rare in a stream, fish will be found primarily not using cover simply because of the rarity of cover, rather than because they are selecting areas without cover. Guay et al. (2000) proposed a modification of the above technique where habitat suitability criteria data are collected both in locations where fish are present and in locations where fish are absent. Criteria are then developed by using a logistic regression with presence or absence of fish as the dependent variable and depth, velocity, cover and adjacent velocity as the independent variables, and all of the data (in both occupied and unoccupied locations) are used in the regression.

Before going out into the field, a data book was prepared with one line for each unoccupied location where depth, velocity, cover and adjacent velocity would be measured. Each line had a distance from the bank, with a range of 0.5 to 10 feet by 0.5 foot increments, with the values produced by a random number generator. In areas that could be sampled up to 20 feet from the bank, the above distances were doubled.

When conducting snorkel surveys adjacent to the bank, one person snorkeled upstream along the bank and placed a weighted, numbered tag at each location where YOY spring-run Chinook salmon or steelhead/rainbow trout were observed. The snorkeler recorded the tag number, the species, the cover code[7] and the number of individuals observed in each 10-20 mm size class on a Poly Vinyl Chloride (PVC) wrist cuff. If one person was snorkeling per habitat unit, the side of the creek to be snorkeled would alternate with each habitat unit and would also include snorkeling the middle portion of some units. As an example, the right bank was snorkeled for

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[6] The adjacent velocity was measured within 2 feet on either side of the location where the velocity was the highest. Two feet was selected based on a mechanism of turbulent mixing transporting invertebrate drift from fast-water areas to adjacent slow-water areas where fry and juvenile salmon and steelhead/rainbow trout reside, taking into account that the size of turbulent eddies is approximately one-half of the mean river depth (Terry Waddle, USGS, personal communication), and assuming that the mean depth of Clear Creek is around 4 feet (i.e., 4 feet x ½ = 2 feet). This measurement was taken to provide the option of using an alternative habitat model which considers adjacent velocities in assessing habitat quality. Adjacent velocity can be an important habitat variable as fish, particularly fry and juveniles, frequently reside in slow-water habitats adjacent to faster water where invertebrate drift is conveyed. Both the residence and adjacent velocity variables are important for fish to minimize the energy expenditure/food intake ratio and maintain growth.

[7] If there was no cover elements (as defined in Table 3) within 1 foot horizontally of the fish location, the cover code was 0.1 (no cover).

one habitat unit, the middle of the next habitat unit was then snorkeled, and then the left bank was snorkeled of the next habitat unit and then the process was repeated.[8] The habitat units were snorkeled working upstream, which is generally the standard for snorkel surveys. In some cases when snorkeling the middle of a habitat unit, the difficulty of snorkeling mid-channel required snorkeling downstream. If three people were going to snorkel each unit, one person snorkeled along each bank working upstream, while the third person snorkeled downstream through the middle of the unit. The distance to be snorkeled was delineated by laying out a tape along the bank as described previously for a distance of 150 feet or 300 feet. The average and maximum distance from the water's edge that was sampled, cover availability in the area sampled (percentage of the area with different cover types) and the length of bank sampled (measured with a 150 or 300-foot-long tape) was also recorded. When three people were snorkeling, cover percentages were collected by each person snorkeling. After completing each unit, the percentages for each person were combined and averaged. The cover coding system used is shown in Table 3.

A 150 or 300-foot-long tape was put out with one end at the location where the snorkeler finished and the other end where the snorkeler began. Three people went up the tape, one with a stadia rod and data book and the other two with a wading rod and velocity meter. At every 20-foot interval along the tape, the person with the stadia rod measured out the distance from the bank given in the data book. If there was a tag within 3 feet of the location, "tag within 3" was recorded on that line in the data book and the people proceeded to the next 20-foot mark on the tape, using the distance from the bank on the next line. If the location was beyond the sampling distance, based on the information recorded by the snorkeler, "beyond sampling distance" was recorded on that line and the recorder went to the next line at that same location, repeating until reaching a line with a distance from the bank within the sampling distance. If there was no tag within 3 feet of that location, one of the people with the wading rod measured the depth, velocity, adjacent velocity and cover at that location. Depth was recorded to the nearest 0.1 foot and average water column velocity and adjacent velocity were recorded to the nearest 0.01 ft/s. Another individual retrieved the tags, measured the depth and mean water column velocity at the tag location, measured the adjacent velocity for the location, and recorded the data for each tag number. Data taken by the snorkeler and the measurer were correlated at each tag location. For the one-snorkeler surveys, the unoccupied data for the mid-channel snorkel surveys was collected by establishing the distance to be snorkeled by laying out the tape on a bank next to the distance of creek that was to be snorkeled. After snorkeling that distance, the line snorkeled was followed down through the middle of the channel and the randomly selected distance at which the unoccupied data was to be collected was measured out toward the left or right bank, alternating with each 20 foot location along the tape. For the three-snorkeler surveys, unoccupied data was collected for each habitat unit snorkeled in this manner by alternating left and right bank or mid-channel for each habitat unit snorkeled. As an example, for the first

[8]The Sacramento Fish and Wildlife Office Instream Flow Group designates left and right bank looking upstream.

habitat unit snorkeled, unoccupied data would be collected along the left bank. At the next unit, data would be collected along the right bank. At the next unit, the data would be collected as described previously using the mid-channel line snorkeled.

Results

To date, there have been 214 observations of YOY spring-run Chinook salmon, and 566 observations of YOY steelhead/rainbow trout (in this case the use of the term observations indicates when a sighting of one or more fish occurred). An observation can include observations of fry (<60 mm in length) and observations of juveniles ($\geq$60 mm). Of the 214 YOY spring-run Chinook salmon observations, there have been 193 spring-run Chinook salmon observations of <60 mm fish and 34 spring-run Chinook salmon observations of $\geq$60 mm fish. Of the 566 YOY steelhead/rainbow trout observations, there have been 279 steelhead/rainbow trout observations of <60 mm fish and 314 steelhead/rainbow trout observations of $\geq$60 mm fish. HSC juvenile rearing data collection for $\geq$60 mm spring-run Chinook salmon may continue in FY 2009.

A total of 1,175 mesohabitat units have been surveyed to date. A total of 156,741 feet of near-bank habitat and 33,524 feet of mid-channel habitat have been sampled to date. Table 5 summarizes the number of feet of different mesohabitat types sampled to date and Table 6 summarizes the number of feet of different cover types sampled to date. We have developed two different groups of cover codes based on snorkel surveys we conducted on the Sacramento River: Cover Group 1 (cover codes 4 and 7 and composite [instream+overhead] cover), and Cover Group 0 (all other cover codes). A total of 98,446 feet of Cover Group 0 and 56,029 feet of Cover Group 1 in near-bank habitat, and 32,509 feet of Cover Group 0 and 750 feet of Cover Group 1 in mid-channel habitat, have been sampled to date.

Biovalidation Data Collection

Fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

In FY 2008, we conducted snorkeling surveys of five of the six spawning sites and five rearing sites to provide data for biological validation of juvenile fall-run Chinook salmon rearing habitat simulation. Five of the six spawning sites were included in this data collection effort since the six spawning sites will also be used in simulating habitat for juvenile rearing in the Lower Alluvial Segment. We used the same methods for conducting the snorkeling surveys as used for collecting HSC data. However, for each occupied and unoccupied location, we recorded the horizontal location within the study sites using a robotic total station and stadia rod with prism. Biovalidation data collection was conducted during three field surveys during FY 2008: March 31-April 3, 2008, June 23-25, 2008, and September 15-17, 2008. We sampled a total of 8,645 feet and collected data for 103 occupied and 214 unoccupied locations. We made 14 observations of fall-run Chinook salmon less than 40 mm, 60 observations of 40-60 mm Chinook, 28 observations of 60-80 mm Chinook and 7 observations of greater than 80 mm Chinook.

Table 5
Distances Sampled for YOY Spring-run Chinook Salmon and
Steelhead/Rainbow Trout HSC Data - Mesohabitat Types

Mesohabitat Type	Near-bank habitat distance sampled (ft)	Mid-channel habitat distance sampled (ft)
Main Channel Glide	4,071	744
Main Channel Pool	66,804	12,993
Main Channel Riffle	31,292	7,011
Main Channel Run	52,065	10,395
Side Channel Glide	0	550
Side Channel Pool	1,180	520
Side Channel Riffle	200	365
Side Channel Run	0	664
Cascade	1,129	282

Table 6
Distances Sampled for YOY Spring-run Chinook Salmon and
Steelhead/Rainbow Trout HSC Data - Cover Types

Cover Type	Near-bank habitat distance sampled (ft)	Mid-channel habitat distance sampled (ft)
None	48,623	18,372
Cobble	14,901	8,763
Boulder	7,835	4,558
Fine Woody	48,153	465
Branches	23,518	376
Log	1,700	38
Overhead	1,461	26
Undercut	3,049	73
Aquatic Vegetation	5,115	616
Rip Rap	0	0
Overhead + instream	45,101	611

Habitat Simulation

Juvenile spring-run Chinook salmon and steelhead/rainbow trout rearing (Upper Alluvial and Canyon Segments)

Once sufficient spring-run Chinook salmon juvenile rearing HSC data have been collected and rearing criteria have been developed, spring-run Chinook salmon and steelhead/rainbow trout rearing habitat will be computed over a range of discharges for the six spawning sites and six rearing sites in the Upper Alluvial and Canyon segments. Completion of this phase of the study and completion of the draft report will be subject to the time required to collect sufficient spring-run Chinook salmon rearing HSC data. Given the small number of observations of juvenile spring-run Chinook salmon gathered to date, it may be necessary to utilize the Clear Creek fall-run Chinook salmon juvenile criteria to be developed, spring-run Chinook salmon juvenile rearing HSC data from another creek or river with characteristics similar to Clear Creek, or conduct transferability tests using Clear Creek fall-run HSC or spring-run rearing HSC from another creek or river. The draft report was partially completed in FY 2008. Pending the collection of sufficient data to develop juvenile spring-run Chinook salmon HSC, we anticipate completing draft and final reports on the 2-D modeling of the spring-run Chinook salmon and steelhead/rainbow trout rearing in the Upper Alluvial and Canyon segments in FY 2009. The Red Bluff Fish and Wildlife Office has requested that a draft report be distributed to interested parties for comment in addition to peer review, as is being done with the Yuba River Study reports.

Fall-run Chinook salmon and steelhead/rainbow trout spawning (Lower Alluvial Segment)

We anticipate completing the hydraulic model production runs for all five study sites over the range of simulation discharges in early FY 2009. At that time, fall-run Chinook salmon and steelhead/rainbow trout spawning habitat will be computed over a range of discharges for the five spawning sites. A draft report and peer review should be completed in FY 2009.

Fall-run Chinook salmon and steelhead/rainbow trout rearing (Lower Alluvial Segment)

We anticipate completing the hydraulic model production runs for all five study sites over the range of simulation discharges in FY 2009. At that time, fall-run Chinook salmon and steelhead/rainbow trout rearing habitat will be computed over a range of discharges for the five spawning sites and five rearing sites. A draft report should be completed in FY 2009.

TUOLUMNE RIVER

In FY 2007, we began an investigation on anadromous salmonid outmigrant habitat in the Tuolumne River between La Grange Dam and river mile 22, using existing Geographic Information System (GIS) data. In January of 2007 the Service's Anadromous Fish Restoration Program office requested a study of floodplain inundation as a function of flow for the entire anadromous reach on the Tuolumne, Stanislaus, Merced or the San Joaquin River, using existing

data. The lower Tuolumne was chosen for this study, as appropriate GIS data from a previous study was available for this area. The flow-inundation area relationship was derived for fall-run Chinook salmon and steelhead/rainbow trout potential outmigration habitat in the Tuolumne River downstream of La Grange Dam. ARC GIS data used for this study was originally developed as part of the Federal Energy Regulatory Commission hydro-relicensing proceedings for the Don Pedro Project (Project No. 2299). The GIS layers used were first developed from aerial photos taken at flows between 100 and 8,400 cubic feet per second (cfs) from 1988 through 1995. Shape files were edited to remove islands and isolated pond areas, which were actually gravel pits. Total area was then recalculated for all the remaining polygons for each flow/layer. A curve was then generated by plotting area in acres versus flow.   We completed a draft report in FY 2007, which was reviewed by Anadromous Fish Restoration Program staff. In FY 2008, we conducted a peer review and finalized the report.

REFERENCES

Guay, J.C., D. Boisclair, D. Rioux, M. Leclerc, M. Lapointe and P. Legendre. 2000.
Development and validation of numerical habitat models for juveniles of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 57:2065-2075.

APPENDIX A
YUBA RIVER JUVENILE CHINOOK SALMON AND
STEELHEAD/RAINBOW TROUT STRANDING SITES

Stranding Site #	MHU #	Stranding Flow (cfs)	Stranding Area (ft^2)
1	179-180	< 400	27144
2	173	685	1400
3	169	2128	253
4	170	2110	7356
5	168	3317	750
7	160-163	< 400	48742
7A	158-159	494	14712
8	141	< 400	14208
8A	141	829	268
8B	142	516	104
9	139/135	3338	3653
10	135	1672	4870
11	137/138	545	9
12	134	< 400	7980
13	131	< 400	7471
15	128	< 400	31534
16	117/119	1667	16434
17	50	307	10337
18	49	354	38045
19	45	2096	4205
20	45	891	3413
21	41, 43, 44	395	29859
22	40	1696	3231
23	37	1879	1057

Stranding Site #	MHU #	Stranding Flow (cfs)	Stranding Area (ft^2)
24	35	991	5433
25	28-33	750	14519
26	201	3597	10279
27	201	1953	16
28	201	2300	1511
29	199	3135	2230
30	194	2707	5625
31	192	1790	1200
32	190	634	1473
33	187	1188	246
34	120	< 400	1800
35	117	1908	2083
36	118	1735	351
37	113	2416	153129
38	113	1175	1000
39	112	4907	3547
40	112	3525	227615
41	112	3993	2068
42	112	1563	1339
43	112	3192	6510
44	94	597	18854
45	96-98	< 400	1219
46	100	1930	38947
47	100-104	2309	20690
48	89	1002	800
49	89	1813	1220

Stranding Site #	MHU #	Stranding Flow (cfs)	Stranding Area (ft^2)
49A	89	857	1200
49B	89	1001	750
50A	89	3069	300
50B	89	2702	15
50C	89	1249	420
51	83	2474	26917
52	82	990	476
53	80	1079	20576
54	80	1060	6600
55A	78	1017	7613
55B	78	3974	330
56	74	1813	150
57	71	1136	250049
58	69	2906	5685
59A	68/69	2698	960
59B	68/69	3409	861
60	63	485	18607
61	59	790	10774
62	56	2247	10989
63A	56	4380	3460
63B	56	2300	224
64	53	1949	9985
65	51	907	15168
66	24	903	3040
67	4	738	100
68	1	467	583